THE -9-1-5 HOUSE
WASHINGTON

Sept. 8, 1972

Mr. Kissinger:

This is the report Mr. David Rockefeller mentioned to you yesterday. If you are pressed for time, he suggests you read the "Conclusion" pp 50-55 and also the 'Natural Gas Supply" section beginning on page 40.

Florence

Outlook for Energy in the United States to 1985

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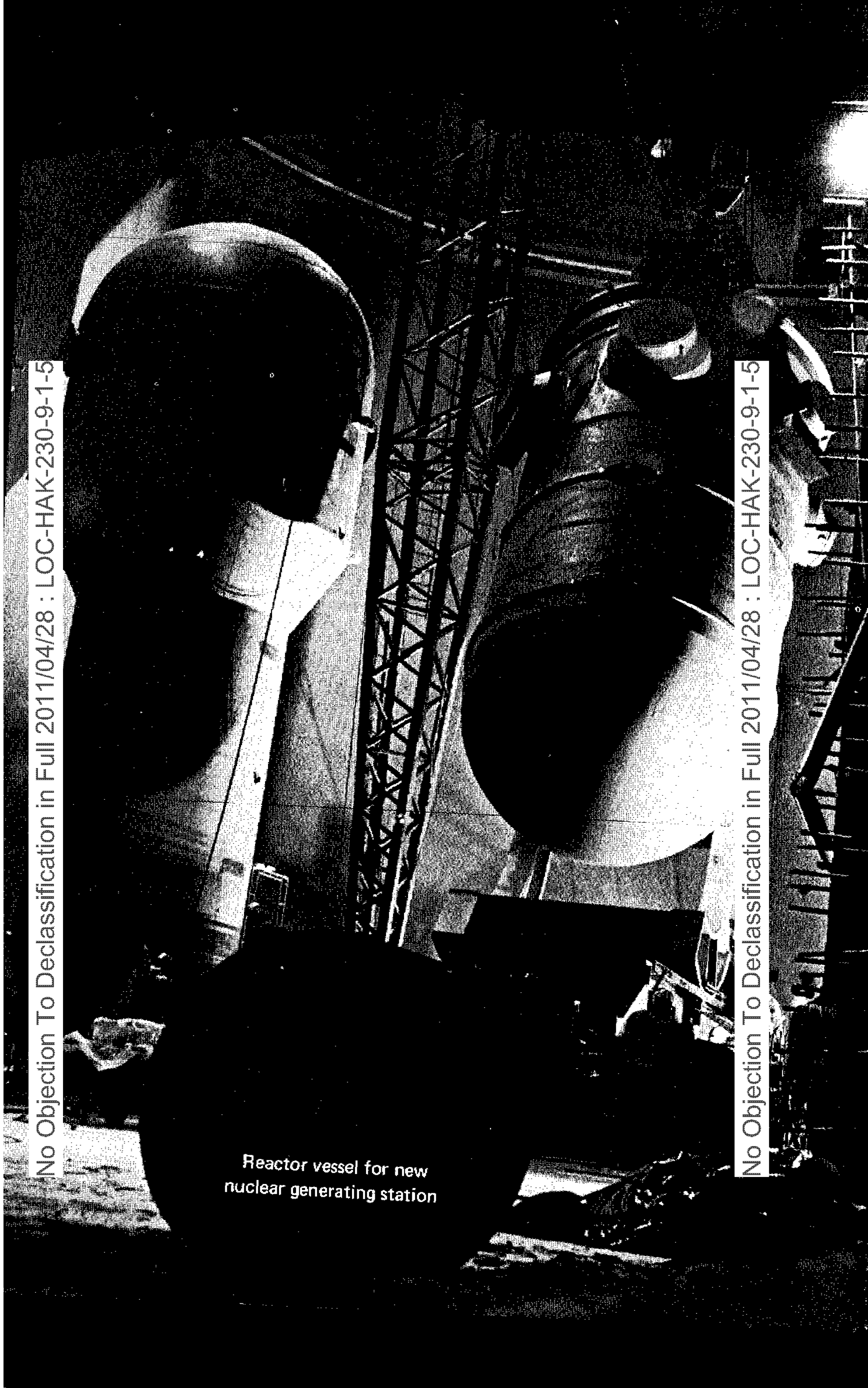

Reactor vessel for new nuclear generating station

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Petroleum pipeline construction activities

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Outlook for Energy in the United States to 1985

by **John G. Winger,** *Vice President*
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Gerald D. Gunning, *Associate Energy Economist*
Richard C. Sparling, *Financial Analyst*
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Energy Economics Division, June 1972

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Open pit coal mining power shovel

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The United States cannot hope to achieve a safe degree of energy self-sufficiency unless a more realistic approach to the solution of environmental problems is also adopted. Improvement of our environment surely is a worthy objective—but not at any cost. To achieve a better environment at the expense of a greater shortage of energy would prove to be a hollow victory, indeed—one the nation simply cannot afford to win. Many actions taken thus far by government and private organizations have limited the current availability of energy and restricted efforts to provide for future needs. And some actions have actually led to a waste of both energy and capital resources. There is a compelling need for all involved to consider with utmost care the ultimate consequences of their actions before further harm is done. Otherwise, a backlash leading to an ugly conflict between the consumers of energy and environmentalists is a likely consequence. And, considering the vastly superior number of consumers, there can be no doubt about the outcome of such an encounter. With a sincere, well conceived, and coordinated effort, the nation can realize environmental gains without sacrificing its supply of energy. But such an effort must be free of political motivations and the influence of special interests, if it is to succeed.

Finally, it must be understood that the energy industries will not be able to serve the nation's needs to the fullest without support and cooperation. Rather than working in harmony for the good of the nation as a whole, government often chooses to play the shortsighted role of adversary instead. Sometimes, these actions of governmental hindrance reflect a lack of knowledge and understanding. But many also leave the clear impression that they are politically motivated. As a nation, we cannot embrace the free enterprise system with one arm and simultaneously reject it with the other. If our chosen system is to function effectively, there must exist a far better understanding of the vital role played by private capital. Like energy, capital is a resource—and it is also in short supply. The current shortage of energy reflects a prolonged shortage of capital—not the lack of an energy resource base. And that is a condition that must be corrected. If it is not, and the energy deficit becomes critical, we have only ourselves to blame. ■

changes are essential—there is no hope that it can be won as long as existing conditions persist. The restrictions that have stifled both the generation of capital and the incentive to invest must be removed at once. From the begining, there was never any logical basis for thinking that the price of natural gas could be regulated without an adverse impact on all forms of energy. And no reasonable excuse can be offered for the failure to take corrective actions in the face of mounting evidence over the past decade and a half of the damage being done. The idea that the consumer was being protected by the regulation has been proven false—instead, by creating an energy shortage, the controls have done the consumer and the nation a great disservice. Therefore, the controls should be removed—not merely modified, but removed completely and quickly. And the prices of all forms of primary energy should be allowed to respond to natural economic forces and move to whatever levels may be necessary to assure an adequate supply.

In addition, there is an urgent need for an understanding by government of the importance of the role played by the provisions for capital recovery. They rank almost equally with net income as a source of capital funds. Together, the provisions for capital recovery and net income provide the great bulk of the money utilized to finance the search for more petroleum and the construction of additional refineries, tankers, pipelines, and marketing facilities needed to serve the nation's petroleum requirements.The lack of a sufficient understanding by government was demonstrated in the Tax Reform Act of 1969. By that legislation, the domestic petroleum industry was deprived of several hundred million dollars of capital funds annually. Based upon past results, the amount of capital lost since the legislation became effective was potentially capable of finding 1 billion barrels of oil and 5 trillion cubic feet of natural gas—enough to satisfy 10 percent of the nation's needs in that period. And now, in the face of a worsening shortage of petroleum, there are actually efforts to reduce the capital recovery provisions even further. The United States can no longer afford politically inspired actions of that nature—the potential harm to the nation is much too great. And the other energy industries, of course, also have a need for realistic capital recovery.

E ·gy is absolutely essential to the welfare of the United Sta Because all human life depends upon energy, the nati could not possibly do without it. Denied a sufficient sup of energy, any developed country would progressively r rt to a primitive state.

A one who doubts the importance of energy should try to i gine what conditions would be like without it. With no ene , the nation's economy would come to a standstill. The would be no production of raw materials, no industrial acti , no manufacturing, and no commercial enterprise. If nor of the primary sources of energy were available, it wou be impossible to generate electricity. And the cou ss needs for electricity everywhere could not be acc modated.

E ause there would be virtually no agricultural activity with energy, very little food could be produced. And the foo ould not be cooked even if it were available. Lacking ene , homes and all other buildings could not be hea —or cooled.

E pt for walking, there would be virtually no means of tran rtation without energy—not even bicycles could be mai actured. Private automobiles, aircraft, trains, trucks, bus ships, and rapid transit systems would all be halted. Nei people nor freight would be able to move.

M t of the activities of government could not be carried on ere were no energy. Schools, churches, hospitals, doc s, and dentists could not function effectively. And mo ommunication would cease. Radio and television sets could not be operated and programs could not be transmitted. Newspapers, magazines, and books could not be printed—there would be no paper, no ink, no power to operate the presses, and no means of delivery. Mail service would be almost nonexistent.

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Without energy, the nation would be virtually defenseless. The vast defense system that has been created at enormous cost would be rendered largely ineffective if its operations were limited by a lack of fuel or if necessary support activities were halted for the same reason. Surely, the perilous nature of that condition must be apparent to all.

Although a total lack of energy is not a realistic pr ect for the United States, there is an actual and g ing potential for an inadequate supply. And a lasting short or even a temporarily interrupted supply can h a devastating impact upon the nation's economy, its sta ard of living, and its defense posture. It is imperative the ore that the future energy needs of the United States a the potential for satisfying them be known. And it has be the purpose of this study to measure as precisely as p ble both the needs and the supply prospects for the iod ranging from 1970 to 1985.

This report is another in a continuing series th was initiated many years ago. It brings up to date and an extension of a similar study published in 1968 that rel to the energy outlook for the 1965-1980 period. Deve ing problems discussed in that report have since becom ore clearly defined. It is now obvious that the United St s is faced with a very serious situation in respect to its rgy supply. And, unless positive corrective actions are ken immediately, the problems will become critical.

Additional copies of this study are available upon request from Th lase Manhattan Bank, 1 Chase Manhattan Plaza, New York, New Yor 015

Photographs used in this study were furnished through the courtesy on- solidation Coal Company, Mobil Oil Corporation and the Atomic In trial Forum.

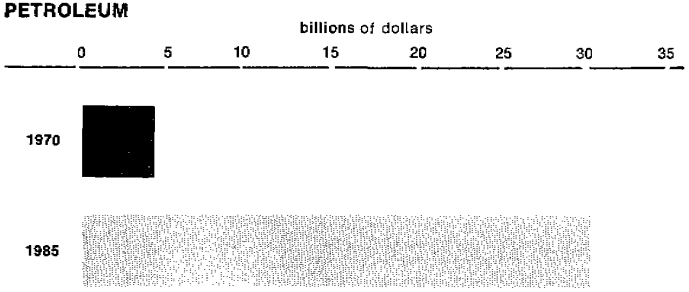
Production control and design coordinated by Norma Anderson, Energy Economics Department, in conjunction with the Graphic Arts Department, The Chase Manhattan Bank.

that the United States has within reach vast energy resources. Although the proved reserves of petroleum—both oil and natural gas—are small relative to future needs, geologists believe there is a potential for finding a great deal more, particularly in offshore areas. How much more actually remains to be found, no one really knows. And the answer cannot be known without a truly exhaustive search. Geologic knowledge has increased enormously since the first discovery of oil 113 years ago. And so has the petroleum industry's technical ability to conduct a thorough search. Because of these developments, petroleum is now found in areas once considered barren or beyond reach. And continuing progress of this nature can be expected. In addition to the potential for finding petroleum by conventional means, huge amounts can be extracted from the oil bearing shale deposits located in the Rocky Mountains. And it is also potentially possible to produce large quantities of synthetic oil and gas from coal in addition to the use of coal in its original form.

But much of the energy resources of the United States is not accessible within the current economic framework. To find, develop, and make available the energy the nation requires, will necessitate the use of vast amounts of private capital. And if the capital funds are to be available, the price structure will have to be adequate. Moreover, it must be flexible—free to change whenever warranted by economic conditions. As a result of the unnatural market conditions created by the price controls imposed on natural gas at the well, the consumers of all forms of energy have been living in a fool's paradise. But time has now run out. And, if they are to have enough energy in the future, they will have to pay prices that are economically sound. Even though such prices will be substantially more than they have been accustomed to paying, the cost of energy nevertheless will remain modest relative to the cost of the other essentials of life. Currently, less than 5 percent of the average family's annual income is devoted to energy—much smaller than the proportions used for food or housing or clothing or taxes.

Clearly, it is vitally important that the United States maintain the highest possible level of self-sufficiency in respect to its energy supply. And, if that goal is to be achieved, major

BALANCE OF PAYMENTS—GROSS OUTFLOW FOR IMPORTED PETROLEUM



bargaining power and would be forced to pay almost any price demanded by the producing countries.

It has been recommended in some quarters that the United States should curb its use of energy as a means of alleviating the shortage of supply. However, an analysis of the uses of energy reveals little scope for major reductions without harm to the nation's economy and its standard of living. The great bulk of the energy is utilized for essential purposes—as much as two-thirds is for business related reasons. And most of the remaining third serves essential private needs. Conceivably, the use of energy for such recreational purposes as vacation travel and the viewing of television might be reduced—but not without widespread economic and political repercussions. There are some minor uses of energy that could be regarded as strictly nonessential—but their elimination would not permit any significant savings. In an emergency, of course, there would be no alternative to a reduction in the use of energy. But, curbing consumption at other times would represent no more than a temporary expediency that would have the unwanted effect of lessening the incentive to find a lasting solution to the problem of an adequate energy supply. And a lasting solution must be found. The United States was able to become the great nation it is because, until recently, it possessed all the energy needed to sustain its enormous productive capacity. But, without enough energy in the future, the nation could not possibly retain its foremost rank.

There is no basis for thinking a lasting solution is impossible. Actually, there are sound reasons for believing

Th ɔurces of Energy

I ıe beginning, man had to depend solely upon his own mu ɔs to provide the energy to satisfy his limited wants an(eds. Later, he discovered new sources of energy to do his rk for him. He learned how to use the energy of the win nd falling water. And he also learned how to harness the ergy of animals. But man's most rewarding discovery wa: e use of fire. For it has been the many and varied uses of t energy released by burning some substance that have dor he most to enrich man's life and raise his standard of livi Without them, most other important discoveries and de pments would not have been possible.

I ı first used fire to keep him warm. And today the use of fire heating continues to rank among the most important of ı ıses. At an early date man also began to use fire for coc g food. And that too continues to be among the most ess ial uses. Fire was also man's earliest source of light. An(ırrently it is still involved in the production of most of the ificial light utilized by man.

I ıpplying the heat of fire to water man learned how to prc ɔe steam, thereby setting the stage for the invention of the ton steam engine and later the turbine steam engine. Wit ıese inventions a vast new world opened up for man. His ɔability for production was increased enormously. For the t time it became possible to manufacture at lower cost a ı ɔ variety of merchandise in large factories with ma ıery powered by steam engines instead of producing a li ɔd amount of expensive goods by hand in small shops or ı ıe home. And the products of the factories could be transported much farther and faster with steam-powered locomotives and ships. Later, man learned how to produce electricity. And steam engines enabled him to generate electricity on a large scale, thereby further expanding his productivity and well-being.

Still another vitally important use of fire began with the invention and development of the internal combustion engine. Once more man's productive capacity was greatly enlarged. And his ability to transport himself and the goods he produced was revolutionized. Today, automobiles, trucks, buses, aircraft, and railroad locomotives are virtually all powered with internal combustion engines. ost agricultural machinery and mobilized construction ip- ment is also powered with such engines.

Clearly, man's controlled use of fire has contr ed enormously to his progress and welfare. Currently, as ch as 86 percent of all the primary energy consumed he United States is devoted to the various methods of u ng combustion. And, obviously, there is an enormous ne for combustible materials. At first, primitive man used wc for burning and for a long time thereafter it continued to an important source of primary energy. But, with the gr ng availability of other sources, the use of wood decline nd there is no longer any significant consumption in the ed States. The ability of coal to support combustio as discovered early in history and eventually coal becar he world's principal source of energy. As recently as 194 oal was still the single most important source of primary e gy utilized in the United States.

Oil was discovered in Pennsylvania in 1859 and for ny years thereafter it was used primarily as a fuel for lamp but with the invention and development of the automob he needs for oil began to expand rapidly. Because it is a id, oil is more versatile than other forms of primary energy id, as a result of that characteristic, many uses for oil r dly developed in industry, commerce, agriculture, an he home. By 1950, oil had displaced coal as the nation's le ng source of energy.

Originally, natural gas was a by-product of the sear for oil. It was found associated with oil and also in reserv by itself. At first, it was considered of little value and for ng time only the gas associated with oil was produced. Part of that production was utilized locally and the rest was simply flared to the atmosphere. But, after World War II, the true value of natural gas as a primary source of energy was recognized and there were vigorous efforts to develop

And, for a period of time, the shortage is certain to become progressively greater. Clearly, the situation is very serious and demands immediate corrective steps. But even if such actions were taken, the shortage would still worsen for several years because of the time that necessarily must elapse before the corrections could possibly become effective and the nation's rapidly growing energy requirements in the meantime.

As indicated in foregoing discussion, the United States depends upon petroleum to satisfy as much as three-fourths of its over-all energy needs. And petroleum is the source of energy in shortest supply. In the opinion of some, the domestic shortage is not a reason for concern because, it is claimed, the United States can import all it needs. Under no logical circumstances, however, could nearly enough natural gas be imported. And, even though a sufficient amount of foreign oil conceivably might be brought in, the nation would be taking a grave risk in doing so. To depend upon uncertain foreign sources for such a high proportion of its oil supply would make no more sense than to expect foreign countries to provide for this nation's defense.

Not only would the United States be in a position of constant weakness, always vulnerable to having a major portion of its oil supply cut off, but it would also suffer from a monumental balance of payments deficit. Currently, the cost of imported petroleum amounts to approximately 4 billion dollars per year. That outflow is more than offset by the repatriated earnings of American petroleum companies operating abroad and the funds derived from the export of related technology and equipment. If the United States is forced to import the amounts of oil and natural gas indicated earlier in this report, the necessary outflow by 1985 is likely to be in excess of 30 billion dollars per year. In no sense would it be realistic to expect that the outflow of dollars would be offset by a corresponding inflow. Indeed, the annual balance of payments deficit for petroleum alone could be as much as 25 billion dollars—a deficit the nation could not tolerate. It could possibly be even greater if foreign producing countries raise their prices more than presently estimated. As a major importer of necessity and with no ready alternatives, the United States would have virtually no

be reduced. It is unlikely, however, that a significant number of such plants could possibly be operating commercially by 1985.

Water Power

Of all the electricity produced in the United States in 1970, approximately 15 percent was generated with water power. In the mountainous areas of the West, where more than half of the nation's hydroelectric capacity is located, water power alone was responsible for nearly sixty percent of the total output of electricity.

Conventional hydroelectric projects involve the control of the water flow of rivers through a system of dams to spin turbines and thus generate electricity. Capital costs are high but operating costs are low. There is no air pollution but environmentalists often object to the construction of dams on other ecological grounds. Another form of water power, developed in recent years, is the pumped storage system. That method involves the pumping of water to an elevated reservoir at a time when the demand for electricity is slack. The water is allowed to flow down through turbines when the demand is at a peak. Although more electricity is required for the pumping process than is generated when the water flows down, greater efficiency is achieved in terms of serving consumer needs. Geothermal energy is still another form of water power. In a few areas in the West, steam rising from hot water trapped deep in the earth is used to produce electricity. The amount that can be thus utilized, however, represents only a tiny fraction of the water power used.

Based upon the relatively few remaining hydroelectric sites that can be developed and effectively utilized, the amount of electricity generated with water power, is not likely to increase by more than 45 percent between 1970 and 1985. By 1985, the electricity thus produced will represent no more than 8 percent of the total amount of electricity generated. And, as a proportion of the over-all supply of primary energy needed, water power is likely to constitute less than 3 percent.

Conclusions

Unfortunately, none of the five domestic sources of primary energy is now adequate to meet the nation's needs.

widespread markets for it. Because of its excellent combustion characteristics and the exceptionally low price charged for it, gas began to be used at a rapidly increasing rate. And, by 1958 it displaced coal as the nation's second most important source of energy.

F ng water was another of man's earliest sources of ene and it continues to be used extensively. At one time the ergy created by the movement of water was applied dire to operate machinery of various kinds. But today it is use most exclusively for generating electricity. Of the total am t of primary energy utilized in the United States cur ly, water power represents nearly 4 percent.

N ear power is the nation's newest source of energy. The ractical application of nuclear power to peaceful pur es became a reality only within the past few years. Wit inor exceptions, the direct use of nuclear energy is limi to the generation of electricity. But for that purpose it pro es to be of rapidly growing importance as time goes on. cause it is so new, nuclear power currently constitutes less an 1 percent of the over-all energy supply in the Uni States. It will, however, become a more significant pro tion in the years ahead. Although heat is involved in the clear reaction, combustion does not occur in the usual sen that is meaningful to the layman.

S tly speaking, anything with the inherent ability to per n work may be called energy. And in that sense, there are ny sources, including human beings and animals. But for ctical reasons, the scope of this study is limited to tho ive primary sources that perform the great bulk of all the tion's work—oil, natural gas, coal, water power, and nuc r energy. There is a tendency on the part of some to thir f electricity as a primary source of energy too. But act y it is not—it is considered a secondary source bec e a primary source necessarily must be utilized to pro e electricity.

Energy as a Raw Material

For the most part, the five sources of energy are used to perform work. But some are utilized for other important purposes as well. For example, most of the organic chemicals produced in the United States are derived from

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petroleum. Coal can also be used as a chemical feedstock. And from these chemicals a wide and rapidly growing range of important products is produced in turn. Petroleum is also utilized extensively as a paving material for the nation's streets, roads, highways, and parking lots. And much of the roofing material used in the United States is produced from petroleum. More than three-fourths of the nation's ı ɔer supply is also derived from petroleum. And the of petroleum as a lubricant is, of course, widely known. It ıso possible to produce food from petroleum. An imp ant ingredient in the manufacture of steel is the coke ı is produced from coal. Currently, these and other u of primary energy as a raw material together repres 10 percent of the over-all consumption of energy in the ted States.

How Energy is Measured

There are various methods of measuring energ ıut, obviously, when several forms of energy are cons ·ed together, a common unit of measurement mu be employed. Because several of the measuremen are technical, they are not meaningful to laymen. Experien ıas demonstrated, however, that the barrel used for mea ing oil is more readily and broadly understood because it the unit most easily visualized. In this report, therefore, the sources of energy will be expressed in barrels oil equivalent. When appropriate, however, other ur of measurement will also be utilized.

The Major Markets

All the various uses for energy are far too numer to discuss individually. But they all fall within one or the o ·of five major market categories. They are listed ow according to their current size:

Energy Market	% of Total
Industrial	32
Electric Utilities	25
Transportation	24
Residential	14
Commercial	5
Total	100

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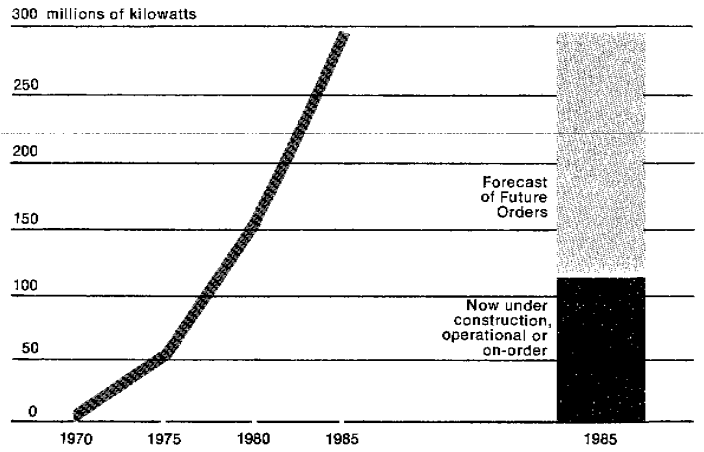
U.S. NUCLEAR GENERATING CAPACITY
Year End



likelihood that any plant orders in addition to those already projected could possibly be operational by 1985.

At present, there is a substantial degree of objection to nuclear power plants on environmental grounds. And the start up of a number of plants has been delayed as a result. Conceivably, such objections could limit the growth of nuclear energy to less than the expected amount. But, it is necessary to be mindful that there are also environmental restrictions on the use of coal and, if the electric utilities were denied sufficient supplies of both nuclear energy and coal, they could not possibly satisfy the nation's needs for electricity. In that event, a direct conflict between consumers and environmentalists would be inevitable.

As a result of a vigorous exploratory effort both in the United States and abroad, there have been significant additions to uranium reserves. And the outlook for the basic raw material used in the production of enriched nuclear fuel has improved. Also, joint private and government sponsored research effort to develop a practical breeder reactor is being accelerated. When perfected, such a unit would have the eventual capability of producing more nuclear fuel than was originally needed to start the plant's operations. And the dependence upon natural uranium reserves would therefore

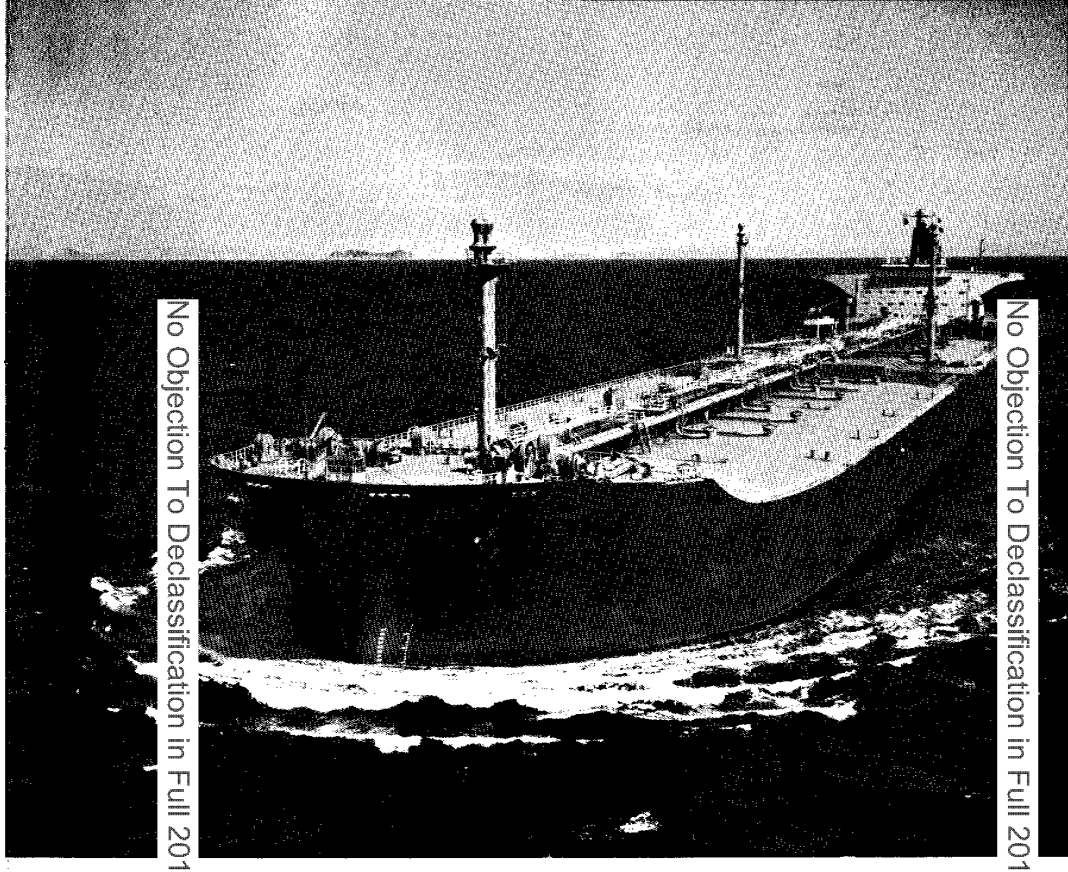
industry. About one-third of the recoverable coal reserves has a sulphur content too high to meet current standards. And, if that coal is to be utilized, the sulphur will have to be removed at a substantial cost when the coal is burned. The coal reserves with a low sulphur content are located largely in the western part of the nation and high transportation costs would be involved in moving the coal to the major markets in the East. To a growing degree, the coal industry will also need to depend upon strip mining, if it is to increase its productive capacity. And the associated costs of land restoration will be high.

Clearly, the capital costs of expanding the nation's coal production will be very large. And, if the required funds are to be generated, the price of coal necessarily will have to be substantially higher than it has been in the past.

Nuclear Energy

Unfortunately, a rather widespread misconception exists in respect to the use of nuclear power. To a surprising degree, there is a tendency to believe that it can be freely substituted for other forms of primary energy. But, in actual fact, that is not possible. The use of nuclear power is virtually limited to the generation of electricity by electric utilities—it is not practical to utilize it directly for industrial, commercial, transportation, and residential purposes. Only to the extent that those markets can readily substitute electricity purchased from utilities for the direct use of primary energy can their needs be satisfied with nuclear power. And there are practical limits to the degree of such substitution.

As noted earlier, the use of nuclear energy to generate electricity is expected to grow at an exceptionally fast rate in the 1970-1985 period. And by 1985, nuclear power is likely to be the foremost form of primary energy utilized to produce electricity, representing as much as 35 percent of the total consumption of the electric utilities. Despite the rapid growth in prospect, nuclear power is not likely to constitute more than 13 percent of the total supply of primary energy required for all purposes. And there is no realistic basis for thinking that it could possibly be a higher proportion. After a nuclear generating plant is ordered, a 7 to 8 year period is required for construction and other details. And there is little



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E tric Utilities are not final consumers of primary energy but tead are processors, converting it to electricity which is t sold to ultimate consumers. Of the total amount of ele ity currently generated, 68 percent is sold to ind ial and commercial consumers who use it for bus ss related purposes. And the remaining 32 percent is sol residential consumers for their various private needs.

A mobiles and all other privately owned vehicles are cur ly responsible for somewhat more than half of the prir y energy consumption in the Transportation market. An rlines, railroads, trucking fleets, buses and all other mo equipment operated for business reasons are responsible for slightly less than half.

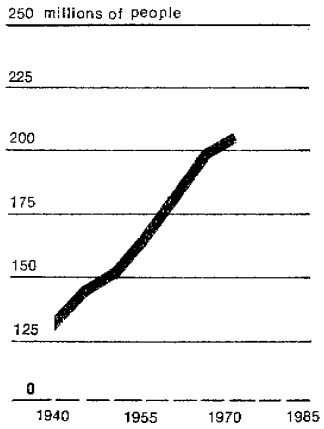
Of the total amount of energy consumed in the United States, both in primary form and as electricity, two-thirds is used for business related purposes and one-third is utilized for all private, nonbusiness needs.

People are Basic

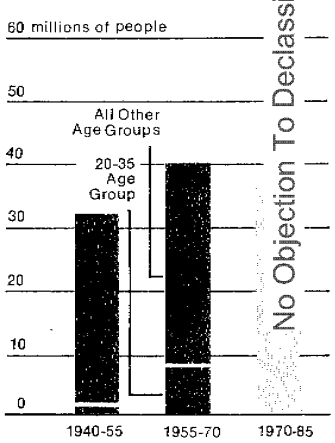
The satisfaction of the needs of people for good nd services is the basic force underlying the nation's eco ıy. And, obviously, the future requirements for energy will ge upon the number of people, their needs, and the res ng economic activity.

Population growth has continued uninterrupted thr ıh- out the history of the United States. And further growt in prospect. The Bureau of the Census has made four se ıte predictions based upon various assumptions in resp to the future birth rate. And one of the more conser ve forecasts has been selected for the purposes of this ly. According to that estimate, the nation's populatio vill increase by 37 million between 1970 and 1985 to re ı a total of 241 million. The population increase is cert to expand the requirements for energy. Not only will t 37

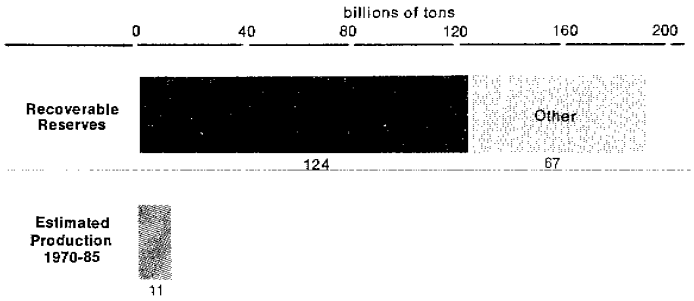
U.S. RESIDENT POPULATION



POPULATION GROWTH



POTENTIAL SUPPLY OF COAL—UNITED STATES



fired steam locomotives to the more efficient diesel engines. On the heels of that development, the coal industry was dealt an even more devastating blow by the rapidly expanding invasion of its other markets by exceedingly low priced natural gas. As noted earlier, the gas was available at an unrealistically small cost because of the price controls imposed at the well. Unable to compete in terms of price, the coal industry experienced a large scale loss of markets.

With declining markets and a very low price received for the coal it was still able to sell, the industry had neither the financial means nor the incentive to develop additional productive capacity. Indeed, it was not even able to maintain existing capacity, as it continued to encounter rising costs of operation. Only the most efficient operations could be sustained. In the mid-Sixties, the industry's outlook was rendered even more bleak when electric utilities began to place a large number of orders for nuclear powered generating stations. And more recently, the use of coal by electric utilities and industrial consumers has been restricted for environmental reasons. Considering all the circumstances of the past 25 years, it is little wonder that the United States is faced with a shortage of coal in the midst of plenty.

If the coal industry is to satisfy all of the expected demand between 1970 and 1985, it must progressively enlarge its productive capacity to nearly double what it is at present. Much of the increase will be needed in the latter part of the 15 year period, when the shortage of natural gas becomes more acute. The need to conform to stringent environmental standards will constitute a major problem for the coal

are heard frequently. Because operating facilities are so highly concentrated in these areas, they are exceedingly vulnerable to both sabotage and military action. And there actually have been frequent incidents in the past that have stopped or reduced the movement of oil to market. In the unfortunate event of a large scale armed conflict between nations, the entire production of the Middle East and Africa conceivably could be halted.

As noted earlier, the great bulk of the supply of both rubber and organic chemicals is derived from petroleum. And, as the nation's self-sufficiency in respect to petroleum progressively declines in the future, so will its self-sufficiency in rubber and chemicals.

Coal

Without any limitations upon the future supply of natural gas, the nation's needs for coal would be expected to grow from 525 million tons in 1970 to 715 million tons in 1985. But, as a result of the shortage of gas and the need to use coal as a substitute, the demand for coal is expected to reach 960 million tons in 1985—about one-third more than would normally be in prospect. The accumulated needs over the 15 year period are expected to be nearly 11 billion tons.

From the standpoint of coal resources, there is positively no question about the adequacy of supply. The total potential resource base is nearly 800 billion tons—enough to last 1,500 years at the current rate of consumption. Although it would not be possible to recover all of this coal with current mining technology and economic conditions, much of it would be available given the proper circumstances. With existing technology, approximately one-fourth of the total potential resource is accessible. And even that amount would last for several hundred years at the current rate of consumption.

Despite the abundance of potentially available coal, the nation is nevertheless on the threshold of a developing shortage. Numerous factors are involved—some economic and some political. Together, they have created for the coal industry a shortage of capital funds similar to that experienced by the petroleum industry. Following World War II, the coal industry suffered a severe loss of market as the nation's railroads progressively converted from coal

million additional people be consuming energy directly, but a great deal more will be used in the process of satisfying all their other needs for goods and services.

Reflecting variations of the birth rate in the past, the number of people in the age group that ranges between 20 and 35 will increase dramatically. It will be a development of gre significance because that age group influences ecc nic activity much more than any other. Within that age spa most marriages occur and consequently most new hou holds are established. Also, the parents of most of the bat born are in that age group. To equip the households and commodate the needs of growing families, a wide ran of products must be purchased. It is indeed the time of life en the need for goods and services is greatest.

t ause the people who will enter the 20 to 35 age group bet en 1970 and 1985 are already living, it is virtually cer that the size of the group in that period will increase by nillion—or as much as 44 percent. Compared with the fift year period immediately preceding, the expansion of the oup will be well over twice as great—and it will be nea eighteen times larger than in the fifteen years before tha Clearly, the economic activity required to satisfy the ind ed needs for goods and services must increase at a rap ate. And, as a result, the needs for energy will expand rap too.

The er Capita Use of Energy

growing economic activity and a rising standard of livi the per capita use of energy has increased steadily in the ist. It has doubled within the last 30 years. And evi ce that it will continue to grow at even a faster rate is unr akable. Each individual consumer will increase his use he continuously strives to improve his living standard. An e average per capita use will surely rise as a result of the eat amount of energy that will be required in the pro is of satisfying the soaring demand for goods and services on the part of the 20 to 35 age group.

Efforts to improve the environmental quality of life will also raise the per capita consumption of energy. If current attitudes continue to prevail, an enormous amount of work will have to be done in the years ahead and a huge amount of

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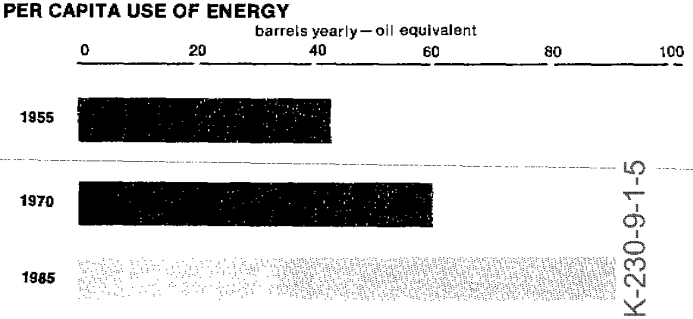
PER CAPITA USE OF ENERGY



energy will be required to achieve the desired resul An additional stimulus to increasing per capita energy u vill be provided by continuing efforts to improve the eco nic and social well-being of the underprivileged. There ar so other progressive changes in the manner of e gy utilization that indicate higher consumption rates per c ta.

Considering all the factors involved, the growth per capita energy use is likely to accelerate in the years a ad. And, by 1985, it is expected to be nearly two-thirds g ter than in 1970. Some of the details are revealed he discussion to follow relating to the growth prospects in each of the five major energy markets.

The Transportation Market

Although it is not the largest of the major energy ma ts, the Transportation market is of prime importance. a significant degree, developments within the other m ets reflect the influence of evolving factors withi he transportation sector.

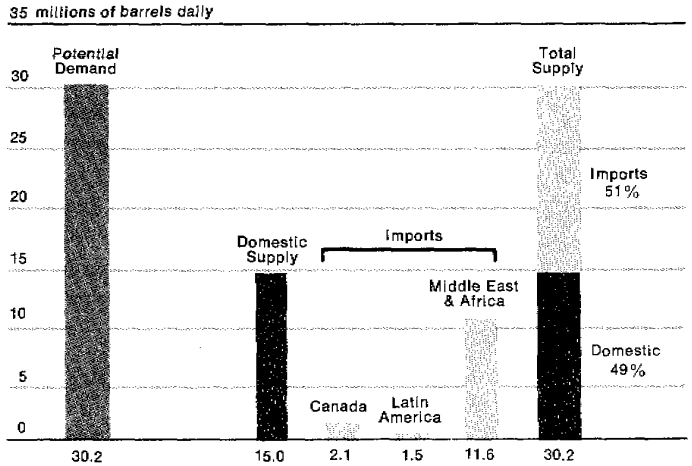
Throughout the history of the United States that infl ce has been evident. Because of the vital need or transportation, the earliest cities were located near ha rs and navigable rivers and lakes. Industrial centers deve ed adjacent to those necessary waterways. And agricultural activities too were carried on nearby.

With the coming of the railroads, however, the dependence upon water transportation gradually diminished. New cities, towns, and villages were built along

Neither Latin America nor Canada will have unlimited amounts of oil to export to the United States. Based upon their existing reserves, realistic projections of future discoveries, and expanding internal needs, the amounts shown in the table represent the maximum likely to be available. Therefore, the great bulk of the imported oil in 1985 will have to be obtained from the Middle East and Africa. The indicated amount from those regions would represent more than three-fourths of all imports and nearly 40 percent of the nation's total supply of oil from all sources.

As demonstrated in earlier discussion, the United States is more dependent upon oil than any other primary source of energy. And it cannot tolerate a prolonged shortage of supply. Even a brief interruption can have a severely damaging impact. As the dependence upon foreign sources of supply increases, so will the potential for supply shortages. And, by 1985, when the nation may have to import more than half of its supply, it will be in a highly vulnerable position. Many of the foreign producing areas have long been the scene of strife and turmoil. And, as past experience teaches, there is the continuing possibility that the movement of oil to market may be halted by governmental action. Threats to cut off or reduce the flow

1985—U.S. OIL SUPPLY AND DEMAND



Oil Supply

If there were no limitations upon the future supply of natural gas, the demand for oil would be expected to grow from 14.7 million barrels per day in 1970 to 26.3 million a day in 1985. But, as a result of the shortage of gas and the need to use oil as a substitute, the demand for oil is expected to reach 30.2 million barrels per day in 1985—nearly 4 million a day more than would normally be in prospect. If the domestic petroleum industry's ability to conduct a search for new sources of petroleum continues to be restricted by a lack of capital funds and other unfavorable economic and political factors, it will become progressively less able to satisfy the nation's needs for oil as well as for natural gas. Based upon the amount of oil that logically could be expected to be found as a result of an 85 billion dollar investment, the nation's productive capability in 1985 is related to the expected demand in the following table:

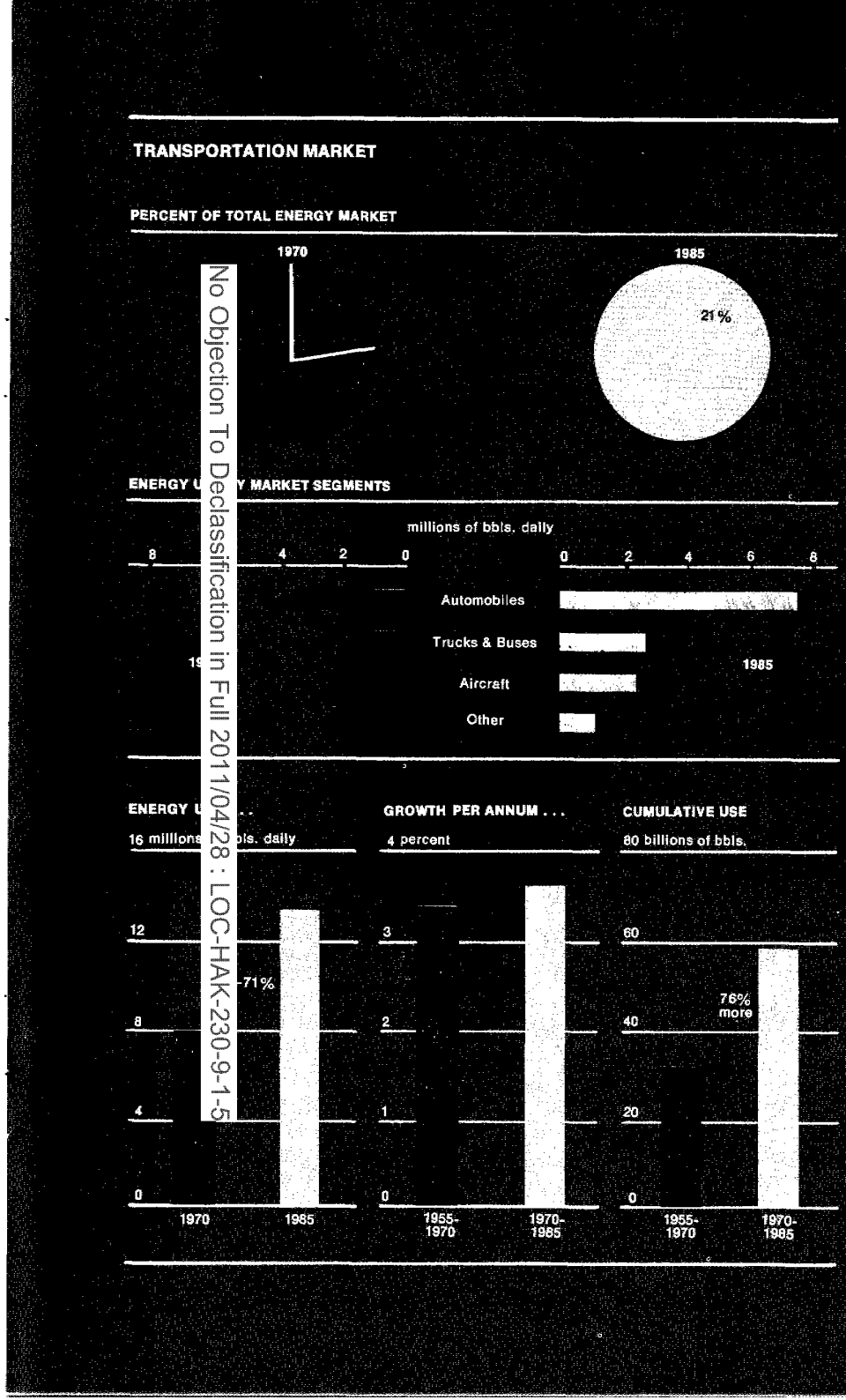
Oil	1970	1985	Change
	Million Barrels Per Day		
Demand	14.7	30.2	+15.5
Domestic Supply*	11.6	15.0	+ 3.4
Deficit	3.1	15.2	+12.1

**Includes Net Processing Gain*

The information conveyed by the table is truly cause for alarm. Clearly evident is a sharp decline in the self-sufficiency of the United States in respect to its supply of oil. In 1970, the nation was capable of satisfying nearly 80 percent of its needs from domestic sources. But, by 1985, it is not likely to be able to satisfy as much as half—*even with the production in Alaska included.* If the market needs are to be fully satisfied in the future, the United States necessarily must become progressively more dependent upon foreign sources of supply. The most likely sources of imported oil in 1985 are shown in the following table:

	Million Barrels Per Day
Latin America	1.5
Canada	2.1
Middle East & Africa*	11.6
Total	15.2

**Includes a fractional amount from the Far East.*



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the routes of the railroads. Industrial operations were concentrated near the hubs of the expanding rail networks. And agricultural activities were conducted in areas that paralleled the railroads.

The progressive development of automobiles, trucks, buses, and aircraft represented other important milestones in the evolution of the nation's transportation system and they have had far-reaching effects in the determinat of where people worked and lived. Within recent year wo separate developments have begun to exert a jor influence and their full impact will become more appai in the years ahead. One is the construction of the rema ɔly efficient Interstate Highway System and the other he extensive use of jet aircraft. Together, these develop nts have provided far greater latitude in terms of ere economic activities can be carried on. The far corners he nation have been brought within easy reach and a ch larger proportion of the land area can be produ ely utilized. No longer must economic expansion necessa be limited to the more congested areas.

History teaches that congestion and pollution have a ys gone hand in hand. When transportation facilities ere limited, congestion and associated pollution of v us forms were to a large degree unavoidable. But wi he opportunities for economic dispersal provided by the n- tinuing improvement and expansion of the nation's trar or- tation facilities there is also the potential for alleviatir he problems of pollution.

For many reasons, the nation's energy requiremer or transportation purposes can be expected to grow a vigorous rate between 1970 and 1985. There will be a g er movement of more people, more raw material, and re finished products over broader areas. Automobiles, t cs, railroads, aircraft, buses and other transportation fa es will all be used more extensively.

The vast majority of working people in the United S es use automobiles for transportation. For most of ther is their only means of getting to and from work. A high proportion of the nation's families need automobiles to carry on essential family business—for shopping, for transporting children to and from school, church, the doctor, the dentist,

reflects the cost of the feedstock and it is therefore highly sensitive to changes in that cost. For the most part, current technology involves the use of naphtha as a feedstock. And, reflecting supply and demand forces, the price of naphtha is increasing sharply. Naphtha is also used as a feedstock in the production of chemicals and increasing competition for available supplies is likely. Additional price advances, therefore, are in prospect. Other light liquids can also be used for gasification purposes, but availability will be limited. In time, a gasification process utilizing crude oil may be developed. But, with domestic supplies becoming increasingly short, the crude oil would have to be imported. Because of a relatively short plant construction time, the gasification of naphtha is the earliest available supplementary source of supply. And, despite the high price of the gas, a number of plants have been announced and others are in the planning stage. By 1985, the total output of such plants is expected to reach 3 billion cubic feet per day.

All of the possible sources of gas supply in 1985 are listed in the following table and their total is compared with the potential demand:

	Billion Cubic Feet Per Day
Domestic Production	60.0
Imports from Canada	5.5
Imports of Liquid Natural Gas	6.5
Coal Gasification	3.5
Oil Gasification	3.0
Total Gas Supply	78.5
Potential Demand	107.0
Supply Deficit	28.5

As the table reveals, the maximum amount of gas—both natural and synthetic—that can realistically be expected to be available by 1985 will fall very much short of indicated market needs. And, unless economic circumstances improve sufficiently to stimulate a much expanded search for new reserves of domestic natural gas, more than a quarter of the market must go unsatisfied. That portion of the market, therefore, will be forced to resort to other sources of primary energy. As discussed earlier in the demand section of this report, oil and coal are the sources likely to be utilized as direct substitutes. That dependence upon oil and coal will be in addition, of course, to the amounts used for gasification, as shown in the foregoing table.

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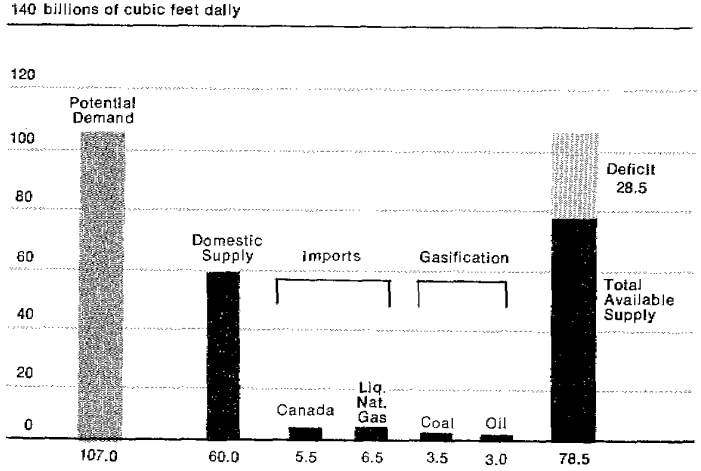
capital costs of a gasification plant are exceedingly high relative to the output of gas. And, at best, the price of the gas at the plant would be several times greater than the current average price of natural gas at the wellhead. Very large scale coal mining operations are required to satisfy the needs of even the smallest economically feasible plant. And the labor requirements are also high, for both the mining and plant operations. In addition, vast quantities of water are needed. Major environmental problems must be resolved in the mining operations and also at the plant. Moreover, approximately one-third of the energy content of the coal is lost in the gasification process. All of the foregoing factors add to the price of synthetic gas, of course. A few plants are currently under consideration for possible construction within the next several years. And research directed toward the development of more advanced gasification technology is being carried on. By 1985, it is possible that 3.5 billion cubic feet per day of synthetic gas produced from coal may be available.

Synthetic gas can also be produced from oil. Although the initial capital investment required is smaller than for liquefied natural gas or for coal gasification, the price of the gas nevertheless is higher. To a major degree, the price

1985—U.S. GAS SUPPLY AND DEMAND



etc. And the family car is by far the most widely used form of transportation for vacation and other recreational travel.

Four-fifths of the nation's households now own at least one automobile and nearly one-third own two or more. By 1985, almost 21 million additional households are in prospect. And the proportion of multicar households is exp ed to rise substantially, too, because much of the pop tion growth is likely to occur in suburban areas and sm r cities rather than in central cities. The ownership of aut obiles by business organizations and government is als estined to increase at a rapid rate. To accommodate the tion's expanding needs for transportation, the total nur r of automobiles in use is expected to increase by nea 50 percent between 1970 and 1985. And the total nur r of trucks and buses is likely to rise by 40 percent.

T e will also be a large increase in the number of lice d drivers. Population studies indicate the likelihood of mo han 150 million by 1985 compared with 111 million in 197 The fuel consumption per licensed driver has risen ste y in the past and the upward trend is expected to cor ue with the increasing dependence upon the aut obile for essential transportation purposes. The huge inc e in the size of the 20-35 age bracket—an age when the e of automobiles is most intensive—will contribute imp antly to the rising fuel consumption per average lice d driver.

T vital role played by the automobile in satisfying the trar ortation needs of the United States is obvious in the foll ig subdivision of the Transportation market accor to major end uses.

ansportation Market	% of Total Fuel Use
utomobiles	53
ucks and Buses	22
rcraft	13
griculture & Off-Road Vehicles	5
ips and Boats	4
Railroads	3
Total	100

As indicated, automobiles consume more energy than all other forms of transportation combined. With the addition of

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trucks and buses, the consumption of all road vehicles represents as much as three-fourths of the over-all energy needs for transportation purposes. And, clearly, it will be the expanding use of such vehicles that will contribute most to the growth of the Transportation market's energy requirements. But the other forms of transportation will all have increasing needs too, particularly aircraft. Refl ng the growth of the nation's economy and continued dis al of economic activity, the business needs for air travel- ith commercial and private—are expected to increase st gly between 1970 and 1985. And vacation travel by air s ld rise too. Barring a major conflict, the fuel requireme of military aircraft are predicted to grow only mode ly, however. The fuel consumption of agricultural mac ry and other off-road vehicles will increase along with od needs and construction activity. Foreign competitio nd limited fuel availability are among factors that will ho he expansion of domestic energy requirements for sh to moderate proportions. To the extent that business act es grow within their reach, the tonnage hauled by railroa vill rise. But their fuel needs will increase only modestly a ey continue to achieve gains in operating efficiency.

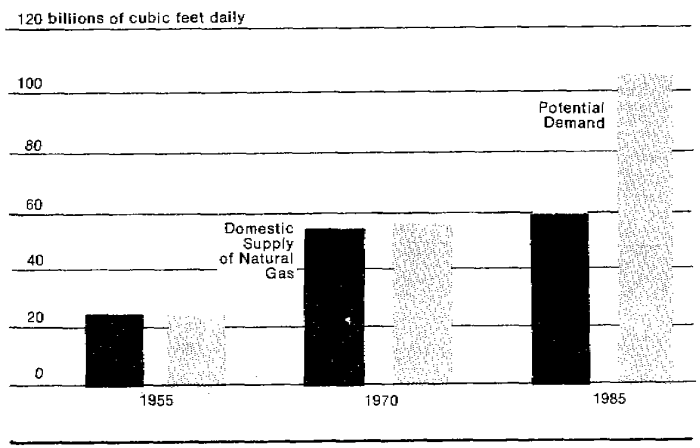
With the exception of a fractional amount of coal us by ships operating on the Great Lakes, the Transpor on market's energy needs are satisfied entirely with c As much as 73 percent is satisfied with gasoline alone an at product is expected to be still satisfying nearly at proportion by 1985. With mounting concern about pol n, various other power systems have been propos as substitutes for the gasoline fueled internal comb on engine. They all have been tested but none has p en practical from an over-all standpoint. Therefore, in al combustion engines are expected to continue to b he dominant automotive power plant, at least until 1985

The higher vehicle manufacturing costs associate ith efforts to increase safety and lessen pollution may lea a reduction in the average size of automobiles purchased in the future. In that event, fuel requirements would be reduced somewhat because of lower weight. But, on the other hand, the efforts to limit the polluting emissions of automobile engines are likely to reduce substantially their operating

Normally, natural gas is transported by pipeline. And the gas imported from Canada is moved by that means. It is, however, possible to convert natural gas to a liquid form by lowering its temperature and, in that form, it can be transported in specially built tankers. If that method of transportation is utilized, natural gas can be imported from several foreign sources. However, because of the exceptionally high costs of the tankers and other necessary facilities, it is a very expensive means of transportation. And the delivered cost of foreign gas to United States markets would therefore be much greater than the current cost of domestic natural gas. As a result of their long history of instability, some of the potential sources of gas supply are widely regarded as unreliable. For that reason and others of a political nature, capital investment tends to be discouraged. And the availability of capital, of course, will be a major factor in the determination of how much liquefied gas will be imported in the future. Some projects are now in the preliminary stage and others may develop in the future. Considering all the factors involved, the imports of liquid natural gas conceivably could reach a total of 6.5 billion cubic feet per day by 1985.

The production of synthetic gas from coal is another potential supplementary source of supply. But, like imported liquefied natural gas, it is a very expensive source. The

U.S. GAS SUPPLY AND DEMAND



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existing economic circumstances, it would not be realistic to expect the petroleum industry to apply more than 85 billion dollars to the search for new sources of petroleum within the 1970-1985 period.

Natural Gas Supply

With the financial input limited to 85 billion dollars, there would be no realistic basis for believing a fully adequate search could be conducted. And the discovery of both oil and natural gas, therefore, would fall far short of indicated needs. Based upon the amount of gas that logically could be expected to be found, the nation's maximum productive capability in 1985 is related to the potential demand in the following table:

Natural Gas	1970	1985	Change
	------Billion Cubic Feet Per Day------		
Potential Demand	59.5	107.0	+47.5
Domestic Supply	56.5	60.0	+ 3.5
Deficit	3.0	47.0	+44.0

As indicated, the nation's self-sufficiency—*even with the production of far away Alaska included*—is not likely to be much over 50 percent. And, obviously, there will be a great need for alternate sources of supply. Of the current over-all supply, gas imported from Canada represents 4 percent. Although the amount of gas brought in from Canada is likely to increase substantially in the years ahead, it will not represent a significantly larger proportion of the total required supply. As in the United States, the future discoveries of natural gas in Canada will reflect both the physical effort to find it and the money available to pay the costs of that effort. In the past, American companies have been responsible for a major part of the expenditures devoted to the search for petroleum in Canada. And the economic forces that determine the availability of funds in the United States also apply in Canada. Based upon existing reserves, a realistic projection of future discoveries, and Canada's internal needs, it is not likely that more than 5.5 billion cubic feet a day of Canadian gas could be imported by 1985. That amount compares with approximately 2 billion cubic feet a day in 1970.

efficiency. And, on balance, the average fuel requirements of automobiles in the years ahead are expected to be higher.

In the following table, the expected growth for each segment of the Transportation market is shown:

	1970	1985	Change	
	Thou.Bbls.Daily		TBD	Percent
Au obiles	4,282	7,395	+3,113	+ 72.7
Tr and Buses	1,741	2,665	+ 924	+ 53.1
Ai ft	1,019	2,415	+1,396	+137.0
Ag ilture and Road Vehicles	387	525	+ 138	+ 35.7
Sh and Boats	336	420	+ 84	+ 25.0
Ra ads	248	295	+ 47	+ 19.0
Total	8,013	13,715	+5,702	+ 71.2

average annual rate of growth for the 15 year period is percent. And the accumulated consumption for the pe l will be 76 percent greater than in the preceding 15 ye

Th ndustrial Market

a major degree, the high standard of living achieved in the nited States reflects the nation's productivity. And its en ous output of goods and services could not possibly be complished without the use of vast amounts of energy. Fo at reason, the Industrial market for energy has always ra d as the single largest of the five major markets listed ea r in this report. Currently, the industrial needs re sent nearly one-third of all primary energy co mption.

he total amount of primary energy utilized by industry, so what more than two-thirds is for purposes of co ustion and the rest is used as a raw material for a wide ra of useful products. By 1985, the proportion used as ra aterial is expected to rise substantially. The increase will occur for a combination of reasons. Between 1970 and 1985, the needs for primary energy as a raw material are expected to nearly double. Much of that growth will reflect the utilization of petroleum as a chemical feedstock—a use that is likely to increase nearly threefold.

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and since that time its annual rates of spending and drilling have fallen progressively farther behind indicated needs. And as a result so has the discovery of both oil and gas.

In the fifteen years ranging from 1955 to 1970, the domestic petroleum industry spent a total of 68 billion dollars on its efforts to find more petroleum. And it drilled a total of 653 thousand wells. For its efforts, the industry found 50 billion barrels of crude oil, 10 billion barrels of other petroleum liquids, and 296 trillion cubic feet of natural gas. In terms of energy value, the gas discovered was the equivalent of 88 percent of the amount of oil found. To have discovered enough oil and gas to satisfy all of the nation's needs during the period and also maintain a realistic inventory of proved reserves, the industry would have had to increase its drilling effort by 75 percent and spend an additional 50 billion dollars. But there is no realistic basis for believing that an expanded effort of such magnitude would have been possible with the existing price structure.

As revealed earlier in this report, the nation's needs for oil and natural gas in the 1970-1985 period will be very much greater than in the preceding fifteen years. And the task of satisfying those needs will be enormous. If they were to be satisfied from domestic sources without any proportional increase in the dependence upon foreign supplies, the petroleum industry would have to carry on a drilling effort more than twice as great as in the preceding fifteen years. And the probable cost of such an effort, including all related activities, would be at least 140 billion dollars—measured in dollars of current value. With continuing inflation, the required outlay would involve a greater number of dollars, of course. Within the existing economic framework, however, there is no likelihood that the industry would be able to finance a search of the required magnitude. The need for capital funds is by no means limited to the amount of money that would have to be devoted to the search for oil and natural gas. As the nation's requirements for petroleum grow, the industry will also have to invest large and steadily increasing amounts for additional transportation, refining, and marketing facilities. It must also pay all operating and capital costs, of course. And the proportions of internally generated funds and borrowed capital must be kept in realistic balance. Considering all the factors involved and the

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expanding needs. In addition, the price regulation badly damaged the incentive to reinvest funds that actually were available. There is clear-cut evidence that the price controls caused capital funds to be diverted instead to other areas of investment, particularly on the part of smaller independent producers.

As a result of the severe controls imposed at the well, natural gas became available in the various energy markets for prices much below the levels at which other forms of energy could effectively compete. Consequently, for a long period of years while accumulated gas supplies remained abundantly available, both oil and coal were excluded from markets. Not only did gas capture most of the over-all energy market growth, but it also displaced oil and coal in existing markets. The impact on the oil and coal industries was both devastating and demoralizing. And it was a major factor contributing to the current shortages.

Quite logically, the amount of petroleum discovered reflects the degree of physical effort to find it. More oil and natural gas will be found if the petroleum industry drills 50 thousand wells in a year instead of 25 thousand. And still more will be found if it drills 100 thousand. It is also logical that there is a relationship between the discovery of petroleum and the amount of money applied to the search. The drilling of wells and all of the associated activities are expensive operations. And often they are unsuccessful. If the market requirements for oil and gas indicate the need to drill 100 thousand wells per year but the petroleum industry has only enough money available to drill 25 thousand, the amount of petroleum found obviously will be much too little.

The amount of money that can be devoted to the search for petroleum depends to a major degree upon the price the petroleum industry receives for crude oil, for natural gas, and for all the refined products it sells. Clearly, if the price of gas had been allowed to reflect its true market value in the past, the petroleum industry would have been able to generate more money from the sale of both natural gas and oil and consequently more could have been devoted to the exploratory and drilling effort. And in that event much more oil and gas doubtless would have been found. The petroleum industry's inability to finance a fully adequate search first became apparent about a decade and a half ago

The industrial use of primary energy for combustion purposes will also grow—but at a slower pace. For several years, industry has progressively satisfied its needs with more electricity purchased from utilities rather than with primary energy consumed directly. Currently, purchased electricity represents more than a quarter of industry's over-all ergy utilization. And, by 1985, it is likely to represent a sul ntially higher proportion. The increase will occur be se, in many cases, industry finds it more expedient to us urchased electricity. And in other cases the severe sh ge of natural gas in prospect will force industry to res in part to electricity as a substitute.

expected growth of industry's direct needs for pri y energy is summarized in the following table:

	1970	1985	Change	
	Thou.Bbls.Daily*		TBD*	Percent
Fo mbustion	7,165	10,105	+2,940	+41.0
Fo w Material	3,392	6,540	+3,148	+92.8
Total	10,557	16,645	+6,088	+57.7

*O uivalent

the 15 year period, the average annual rate of growth is percent. And the accumulated consumption will be 63 pe nt greater than in the preceding 15 years.

ough the figures shown in the table are expressed in te of oil equivalent, the industrial use of primary energy is no means limited to oil. Actually, natural gas is in try's single most important source of energy. Of current ne , natural gas satisfies 49 percent, oil 29 percent, and co 2 percent. In the case of both oil and coal, more than ha s used as raw material rather than for purposes of co ustion. But, in the case of natural gas, little more than on enth is used as raw material.

cause of developing shortages, industry will not be able to rease its use of natural gas to any significant degree. And by 1985, gas as a proportion of industry's over-all supply of primary energy is likely to shrink to little more than one-third. Therefore, industry can be expected to depend upon oil to satisfy much of its expanding needs. As a result, oil use is likely to increase by more than 150 percent

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between 1970 and 1985. And in the latter year it will represent almost half of the total industrial use of primary energy. The consumption of coal will expand too—but by a much smaller degree. The solid form of coal makes it less attractive from the standpoint of both combustion and storage. And environmental factors also operate against the use of coal. Consumption in 1985 is expected to be abo 5 percent greater than in 1970.

The Commercial Market

All forms of commercial enterprise—retail estat ı- ments, wholesale organizations, office buildings, se e activities, hotels, apartment buildings, institutions an o forth comprise another of the major markets for pri y energy. Despite its complex structure, however, it i e smallest of the five major markets. In fact, the Comme al market's primary energy needs are not even one-six is large as industry's.

For the most part, the primary energy utilized in the C ı- mercial market is for space heating. And most other er y needs are largely satisfied with electricity. Actually, the e of energy in the form of electricity exceeds somewha e total amount of primary energy consumed.

Two sources of primary energy—natural gas d oil—serve virtually all the requirements of the Comme al market. Of the total current needs, natural gas sati s about 60 percent and oil most of the rest. Despite the i- ted supplies of gas, these proportions are not expect o change significantly in the future. Gas used for s e heating generally commands a better price than it do n many industrial applications. And, to the extent practica s likely to be reserved increasingly for heating purpose

By 1985, the Commercial market's needs for pri y energy are expected to be nearly 75 percent greater th n 1970. And between those years the average annual ra of growth will be 3.7 percent. The accumulated consumption for the 15 years will be more than twice as large as in the preceding 15 year period.

Because energy is absolutely essential to the welfare of the United States, the continuing availability of an adequate supply is a matter of vital importance. Properly, all consumers—business and private, large and small—should be concerned. And surely it is the obligation of government to accord no less than the highest priority to the matter of energy supply.

In actual fact, however, the subject of energy supply is treated with complacency. Most consumers take for granted the continuing availability of all they require. And government has exhibited only sporadic and superficial interest. Even worse, government has taken actions that have proven highly detrimental to the supply of energy.

Petroleum

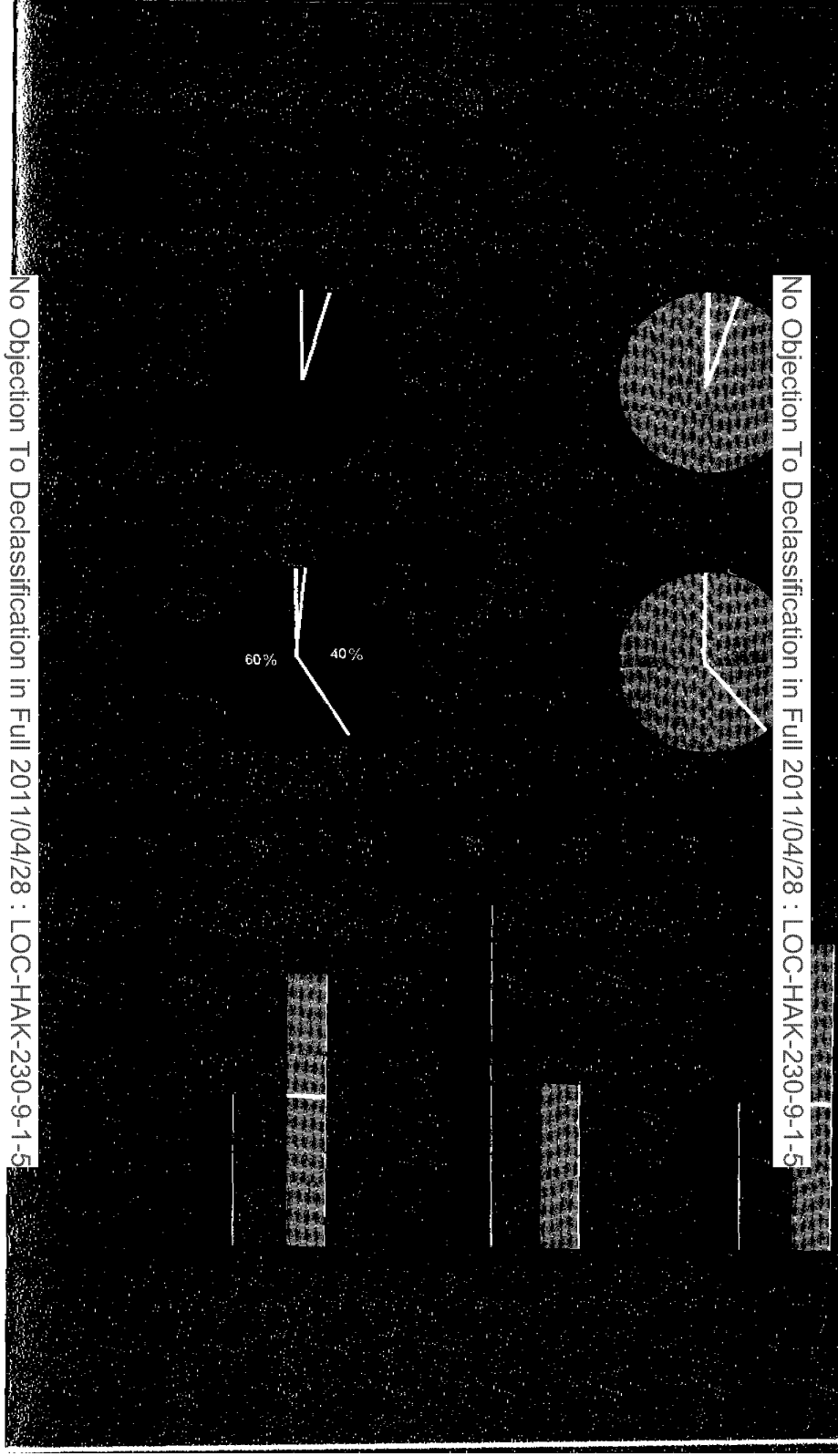
Petroleum—oil and natural gas together—is the nation's foremost source of primary energy. It satisfies as much as three-fourths of the energy requirements for all purposes. Unfortunately, both oil and natural gas are now in short supply. Domestic production is not sufficient to meet current needs—and the deficit is certain to become progressively worse in the years ahead.

The shortage of petroleum is the ultimate result of a series of interrelated developments precipitated by governmental price controls. For a long period of time, the Federal government has controlled the wellhead price of all natural gas moving in interstate commerce. Reflecting political motivations and insufficient regard for the damaging consequences of its actions, the government has consistently held the wellhead price of gas at an incredibly low level. And, in so doing, it has severely restricted the petroleum industry's ability to generate the capital funds required to finance a continuing search for oil and natural gas of the magnitude necessary to keep pace with the nation's

another cause. Congestion and all its associated costs constitute an additional reason. Another factor, closely related to congestion, is inadequate and unreliable local transportation. Pollution, a product of congestion, will have an impact in various forms—there will be efforts to escape pollution by leaving it behind, there will be attempts to minimize it by dispersal, and overly restrictive controls will force the relocation of economic activity. Water shortages and climatic conditions represent still another reason for movement. And changing market conditions and marketing practice are a force of growing importance. As discussed earlier, the development of the nation's transportation system has had a major influence on the economy of the United States. And it will surely continue to do so. The much improved transportation possibilities provided by the Interstate Highway System and jet aircraft can be expected to promote and facilitate continued dispersal of the nation's economic activities over broader geographical areas.

One more factor of major importance is the availability of energy. Because the availability of primary energy is so vital, not only to future growth but also continued existence, it is certain to play a rapidly increasing role in the determination of where economic activities are located. And intensified competition for available energy supply—particularly in the preferred form—can be expected in the years ahead. The East Coast and the North Central regions are deficit areas in respect to primary energy—they both consume far more than they produce within their borders. And they are, therefore, relatively more vulnerable in the event of energy shortages. Although not widely recognized at present, that is a fact certain to become increasingly apparent to consumers as time goes on. And reactions can be expected.

For the reasons cited above, along with others, the demand for primary energy in the 1970-85 period is expected to grow at a faster rate in the southern half of the nation than in the northern half. There will also be changes in the proportions of the primary sources of energy utilized in the five regions. The progressive development of nuclear power as an important source of primary energy will be one factor. And the evolving shortage of natural gas will be another. By 1985, gas will represent a much smaller proportion of the total energy utilization in all regions.



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The Residential Market

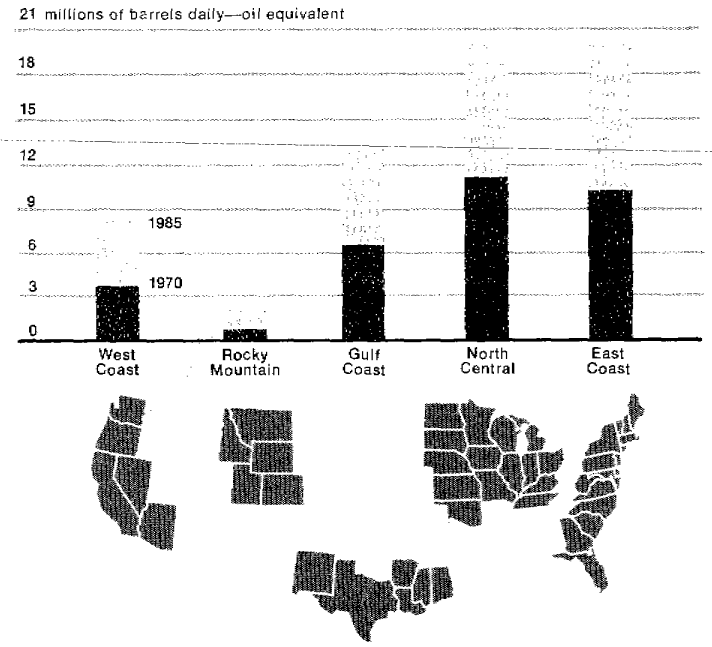
Individual dwelling units of all types comprise the Residential market. The bulk of the primary energy utilized is for heating, with lesser amounts required for cooking, water heating, clothes drying, and miscellaneous purposes. In addition to the direct consumption of primary energy, the Residential market also uses large quantities of ic- tricity—more than one-third of its over-all needs for e gy is satisifed with electricity.

Obviously, as the nation's population expands he Residential market for primary energy will increase to he size of the market will also be influenced by er demographic factors. Certain age groups choose to in apartments and others find their needs are best serve ith individual dwellings. The 20 to 25 and over 60 age g ps generally prefer apartments while individual dwelling ire usually the choice of the 25 to 60 group. Buyers o ew homes are heavily concentrated in the 25 to 35 age in. Reflecting earlier changes in the birth rate, the numl of families preferring individual dwellings will increase ch more between 1970 and 1985 than will the numt of apartment-prone families. And the bulk of that gro is likely to occur in regions where single family ne construction is not limited by congestion and scar of land. Because the energy requirements of indi ial dwellings are greater than the needs of apartments, t er capita use of energy in the Residential market will the re rise substantially.

The combined effects of 37 million more peop 21 million more households, and a higher proporti of individual dwellings are expected to increase the Resic ial market's primary energy requirements by nearly 50 p nt between 1970 and 1985. The average annual rate of g th for the period will be 2.7 percent and the accum ed consumption will be 47% greater than in the 15 rs immediately preceding.

In the beginning, and for a long time thereafter, wood was the single most important source of primary energy for the Residential market. As recently as 1940, wood still satisfied nearly a quarter of the over-all needs. But, by that time, the

TOTAL ENERGY MARKET BY REGIONS



nationwide consumption. The North Central region ranks second with 28 percent. For natural gas, the Gulf Coast is the largest market and the North Central region is almost as large. Together, they account for two-thirds of the total consumption of gas. More than half of all coal consumption occurs in the North Central region alone and more than one-third on the East Coast. Relatively little is utilized elsewhere. The mountains on the West Coast are the source of as much as 59 percent of the nation's water power, with much smaller proportions located in the other four regions. Thus far, very little nuclear power is utilized, and most of that is in the East Coast and North Central regions.

For numerous reasons, the nation's regional energy needs are expected to undergo progressive change between 1970 and 1985. Several factors are likely to motivate economic migration. Oppressive taxation will continue to cause economic activities to take flight and so will labor strife. The relative availability and cost of qualified labor is

Although the East Coast has the largest share of the nation's population, it does not account for the largest proportion of over-all energy use. In fact, it has the smallest per capita consumption of the five regions. But the Gulf Coast, with little more than an eighth of the nation's population, nevertheless accounts for a fifth of the total energy use and has by far the highest per capita rate of consumption.

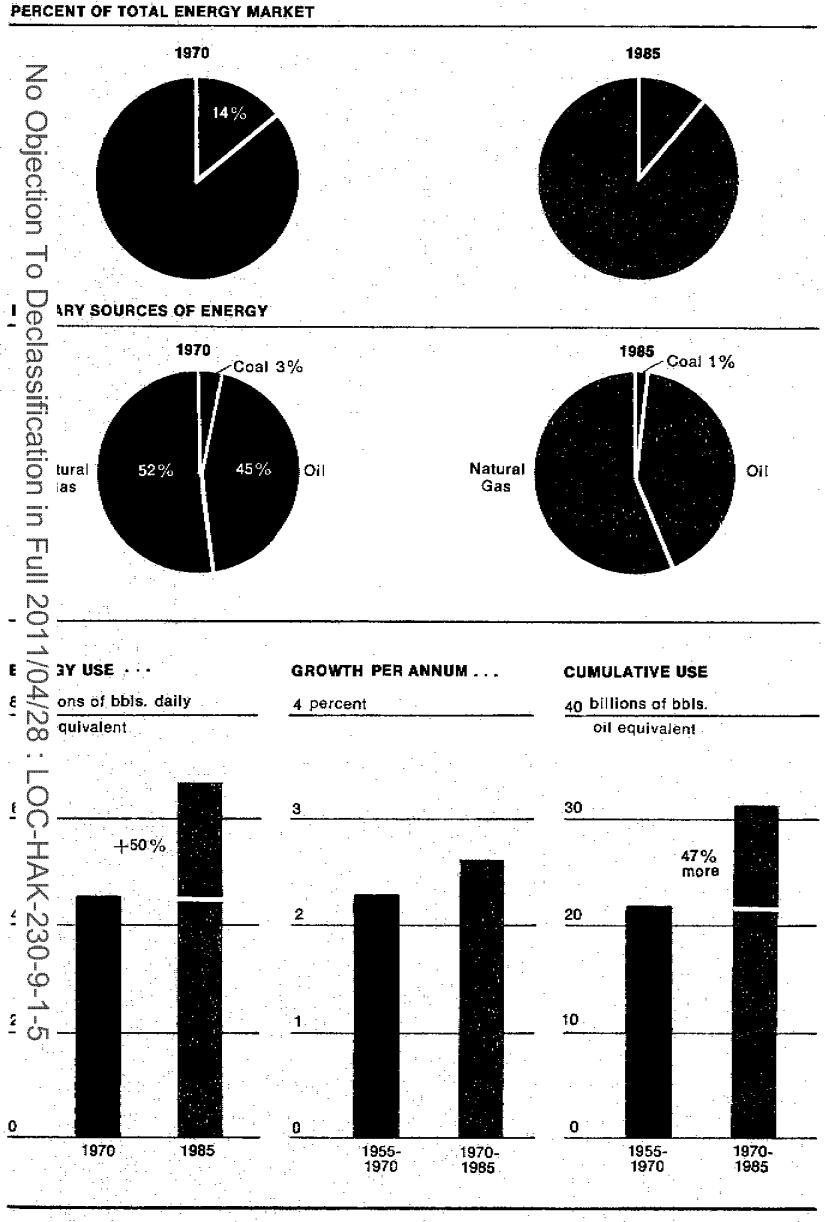
The differences in per capita use indicated in the table reflect the regional distribution of the five major markets for primary energy. As indicated earlier, the Industrial market is the largest of the five. And more than one-third of that entire market is located on the Gulf Coast. Almost another third is located in the North Central region, but less than a quarter exists on the East Coast. Of the total Electric Utilities market, more than a third is in the North Central region with almost another third on the East Coast. Although the single largest segment of the Transportation market—about one-third—exists on the East Coast, the per capita use of energy for transportation purposes is smallest in that region. Nearly another third is located in the North Central region. Because the primary energy needs of both the Residential and the Commercial markets are mainly for space heating purposes, those markets are largest in the colder regions. The North Central region is the largest Residential market and the East Coast is the next largest. But, in respect to the Commercial market, their positions are reversed.

The regional use of the five primary sources of energy also varies substantially, as indicated in the following table:

	East Coast	North Central	Gulf Coast	Rocky Mountain	West Coast
	Percent of Total Energy Used				
Oil	57	36	37	40	48
Natural Gas	17	31	55	34	33
Coal	23	31	7	16	1
Water Power	2	1	1	10	18
Nuclear	1	1	–	–	–
Total	100	100	100	100	100

Obvious is the East Coast's heavy dependence upon oil. In fact, the East Coast is the single largest regional market for oil, accounting for as much as 40 percent of the

RESIDENTIAL MARKET



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superior qualities of coal had become broadly recognized and it was serving well over half of the Residential market's requirements. After World War II, oil briefly took over the lead but the rapidly growing availability of natural gas at bargain prices soon enabled it to move into the forefront. And gas now represents 52 percent of the primary energy used for residential purposes. Oil represents 45 percen d coal only 3 percent.

Because natural gas is widely regarded as a premiun el for residential use, it is likely to retain its lead position i e years ahead despite limited supplies. For various reasc it is realistic to expect that residential consumers wi e accorded top priority in respect to available supplies. is also expected to hold approximately its present share c e market. But the direct burning of coal as such is like o cease. Coal will not be eliminated entirely from the ma t, however, because there is the likelihood that some w e converted to synthetic gas and used in that more attra e form.

The Electric Utilities Market

Huge amounts of primary energy are used in the pro is of generating electricity. And the nation's electric ut is now rank second only to industry as a market for pri y energy. They are also the fastest growing market an y 1985 are expected to constitute the largest of all the r or markets by a wide margin.

Electricity is the most versatile form of energy. It is d for many purposes by virtually everyone in all walks o e. And the dynamic pace of technological progress conti is to develop new uses—in the home and in business. er capita consumption of electricity more than dou d between 1955 and 1970. And there is the likelihood that il rise even more than that in the following 15 years.

As indicated in foregoing discussion, the Indus l, Commercial, and Residential markets all require e amounts of electricity in addition to their direct use of primary energy. And their use of electricity is growing faster than their consumption of primary energy. To some degree, the electricity is utilized for purposes that can be satisfied in no other way. But, in other cases, electricity is used instead

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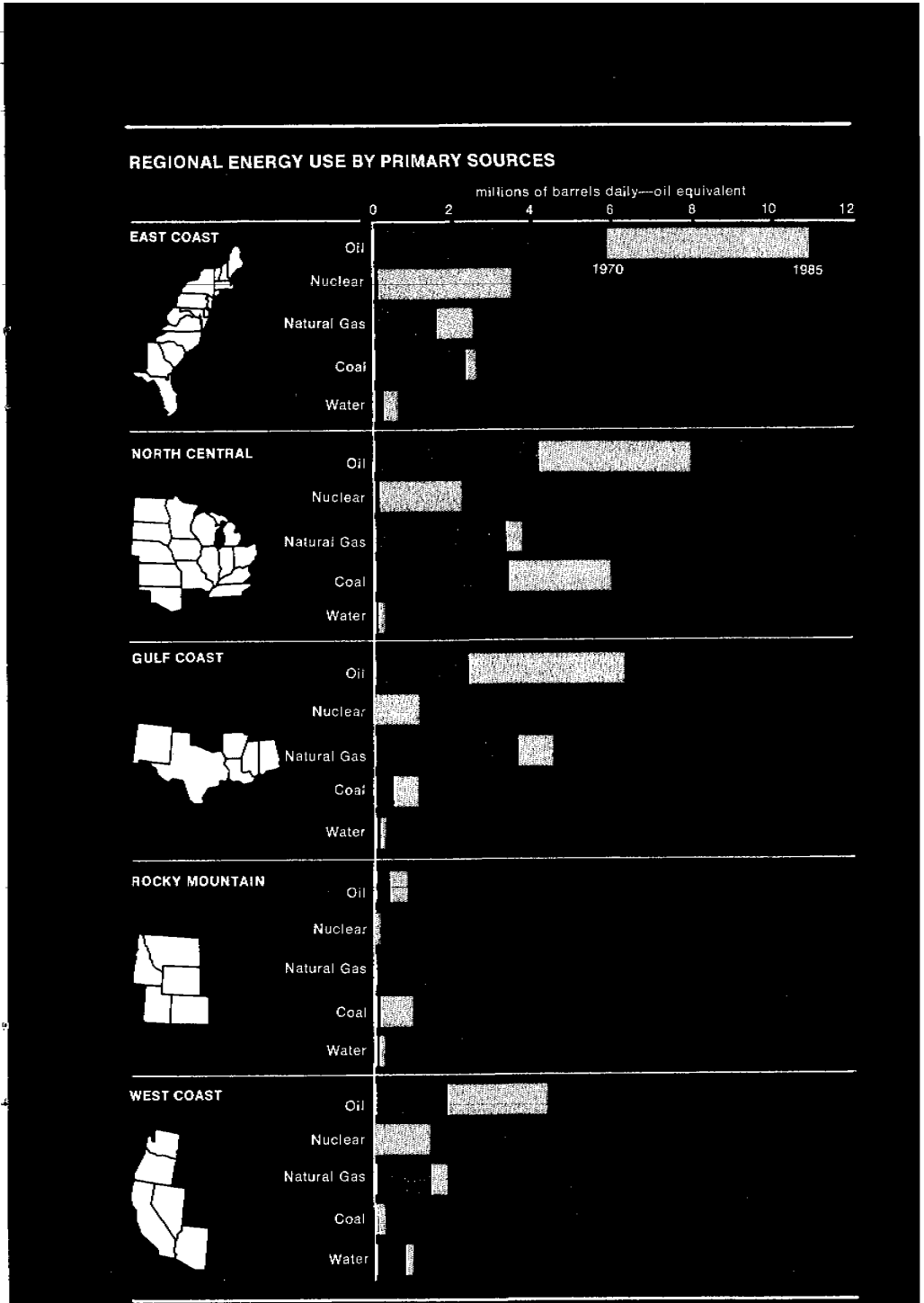


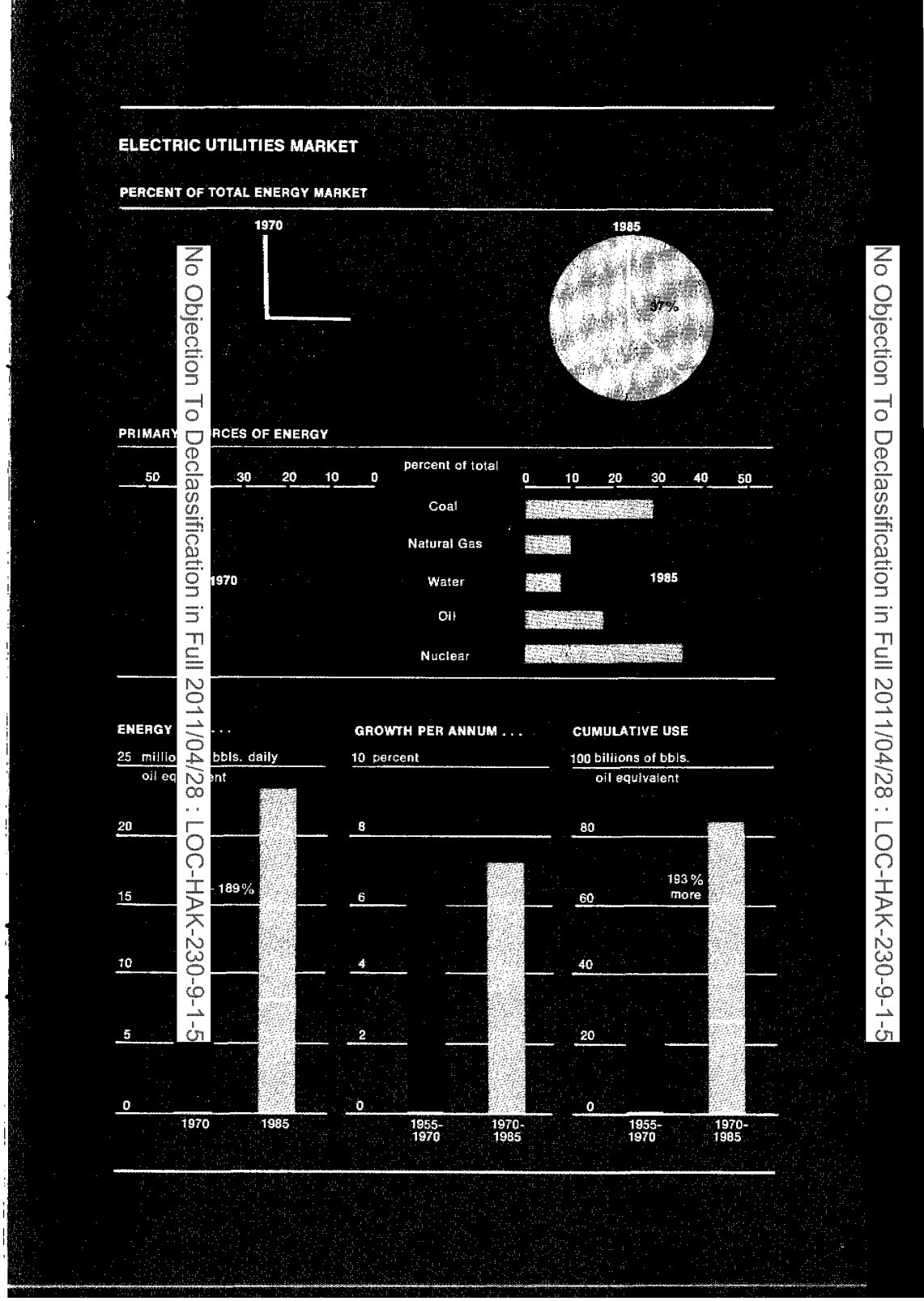
ceptionally strong increase in the demand for oil reflects the rapidly developing shortage of natural gas. If there were no supply limitations, the potential demand for gas in 1985 would be nearly 50 percent greater than indicated in the foregoing table. Natural gas is truly a premium fuel and is much preferred by a wide range of consumers. But, under no realistic circumstances, can the supply of gas be expected to be adequate for the full potential demand. And consumers, therefore, will be forced to substitute other sources of primary energy. An end-use analysis indicates they are likely to fill nearly two-thirds of the gas deficit with oil and the rest with coal. As a result, the demand for oil in 1985 will be 15 percent larger than might normally be expected and the demand for coal will be nearly a third greater. For the most part, the additional oil and coal will be used as such. But, to some degree, both are likely to be converted to a synthetic gas and burned in that form.

The Five Regions

Because the United States is so large in area, with widely varying geographic conditions, population concentrations, and economic activities, the requirements for energy are by no means uniform throughout the nation. The nature of energy end-use, the sources of energy utilized, and per capita use all vary substantially from region to region. It is necessary, therefore, to study regional needs on a detailed basis in the process of determining the future energy requirements for the nation as a whole. For the purposes of this report, the United States is divided into five major geographical regions. They are listed in the following table along with related population and energy data for 1970:

Region	Population	Energy Use	Per Capita Use
	—Percent of Total U.S.—		Barrels Per Year*
East Coast	39	31	47
North Central	33	34	61
Gulf Coast	12	20	101
Rocky Mountain	2	3	69
West Coast**	14	12	51
Total U.S.	100	100	59

**Oil Equivalent*
***Includes Alaska & Hawaii*



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of primary energy. And, when that happens, the demand for primary energy is transferred from the other major markets to the Electric Utility market. In fact, the over-all demand actually is increased somewhat because the use of energy in the form of electricity for such purposes as heating is less efficient than the direct burning of primary energy.

To some extent, consumers denied a sufficient supp[l]y of natural gas will turn to electricity as a substitute. An[d] r pollution restrictions are also likely to necessitate e substitution of electricity for the direct burning of fossil s in some geographical areas. Large quantities of elect[ri]c y will also be required for other environmental purposes n as recycling, waste treatment, and so forth. Huge and ra[pi]d y increasing amounts of electricity consumed in the proce[ss] of enriching uranium fuel for nuclear power plants [wi]ll constitute another important new use.

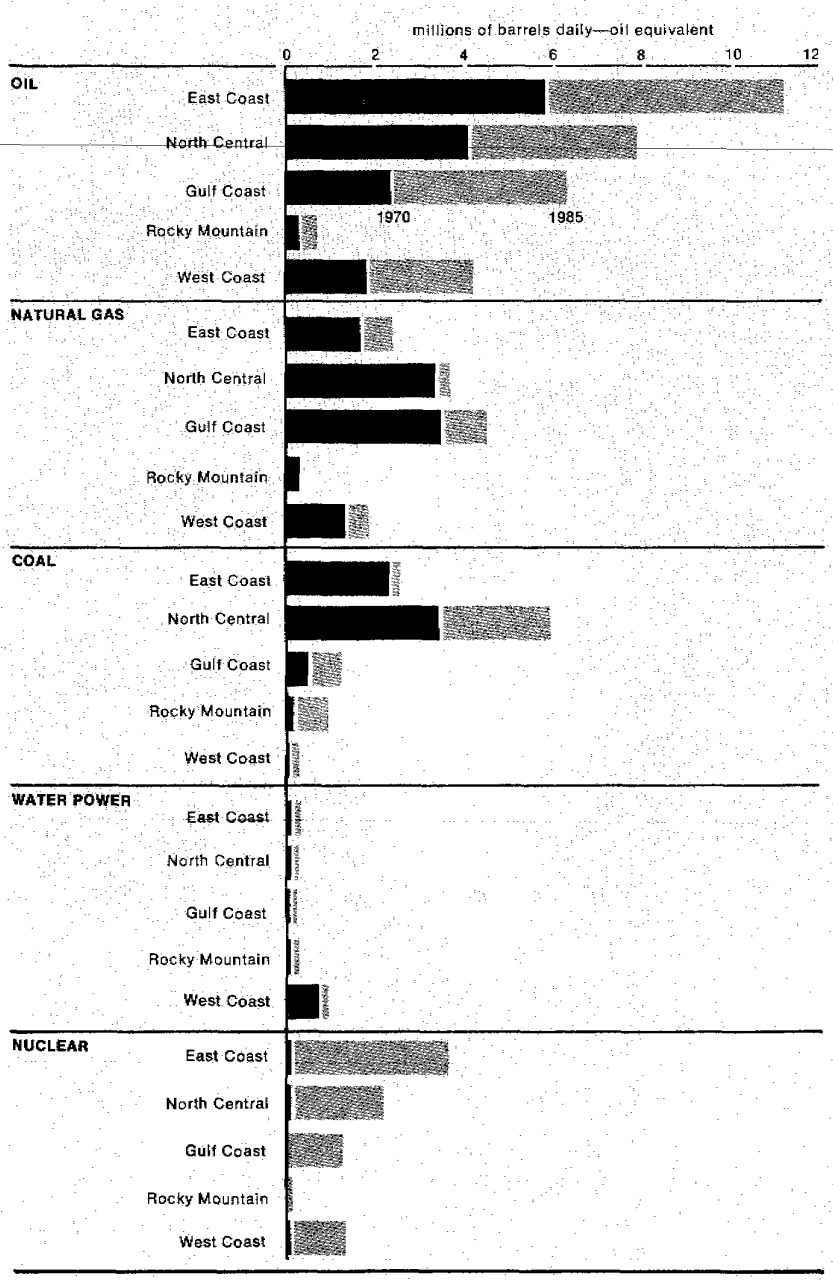
The nation's over-all requirements for electricity by [19]85 are expected to be more than three times greater tha[n] n 1970. And, to accommodate that growth, the electric uti[li]ty s will also need to increase their consumption of primar[y] - ergy nearly threefold. The latter increase will represe[nt] n average annual growth of 7.3 percent. And the accumul[at]ed d consumption over the 15 year period will be almost t[hr]ee e times greater than in the preceding 15 years.

The Electric Utility market is the only one that uses al[l] e of the primary sources of energy. Currently, almost half s total requirements is satisfied with coal and nearly a qu[ar]ter r with natural gas. Water power, oil, and a small amou[nt] of nuclear power serve the remainder of its needs. In the y[ea]rs s ahead, however, these proportions are destined to ch[an]ge e drastically, as indicated in the following table:

Market Share	1970	1985
	---- Percent ----	
Coal	49	29
Natural Gas	24	11
Water Power	15	8
Oil	11	17
Nuclear	1	35
Total	100	100

Electric Utilities have ordered a large number of nuclear powered generating plants scheduled for delivery in the near

PRIMARY ENERGY USE BY REGIONS



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All the Primary Sources of Energy Together

In the following table, the actual consumption of the five sources of primary energy in 1970 is compared with their predicted use in 1985:

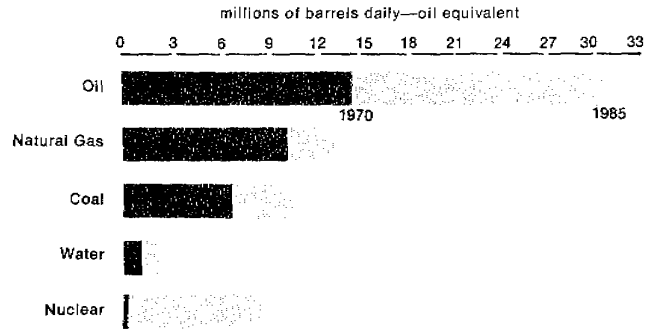
	1970	1985	Change	
	Thou.Bbls.Daily*		TBD*	Percent
Oil	14,709	30,170	+15,461	+105.1
Natural Gas	10,417	12,830	+ 2,413	+ 23.2
Coal	6,497	10,555	+ 4,058	+ 62.4
Water Power	1,247	1,805	+ 558	+ 44.7
Nuclear	110	8,355	+ 8,245	+659.5
Total	32,980	63,715	+30,735	+ 93.2

**Oil Equivalent*

Oil was the largest source of primary energy in 1970, and will continue to be in 1985, because it is so versatile. Among the sources of primary energy, oil is the only one that is used in all five of the major markets. And it is virtually the only source that can serve the Transportation market's needs. Conceivably, coal might also be utilized as a fuel for transportation purposes—but it would have to be converted to a liquid first.

Of the over-all growth of the nation's energy needs between 1970 and 1985, oil alone is expected to accommodate half. To a significant degree, the ex-

ENERGY USE — By Sources



future. And many additional orders are in the planning stage and likely to be placed soon. By 1985, nuclear power is expected to emerge as the single largest source of primary energy used to generate electricity. And, of the increase in the over-all requirements of the Electric Utility market between 1970 and 1985, nuclear power alone is expected to ac ımodate more than half.

ıough the use of coal is expected to rise by 75 percent, co share of the market will decline from half to less than on ıird. Environmental factors, affecting both production an :onsumption, will restrict coal's growth to less than wc I otherwise be anticipated. Because of supply lir ions, the burning of natural gas for generating ele city will expand relatively little. And most of that limited gr h will occur in areas near the sources of gas pr ction. As a result, the share of the market now satisfied wi as will be cut more than in half. Oil's share, on the other ha is likely to increase. In fact, the consumption of oil is ex :ted to expand more than fourfold by 1985. En ınmental factors, economic forces, and a lack of na ıl gas are among the reasons favoring the dynamic gr h in prospect for oil. Although water power ranked as th econd most important source of primary energy for ge ating electricity only two decades ago, it will become th ast important by 1985. The number of potential dam sit emaining to be developed will limit the expansion of hy electric capacity between 1970 and 1985 to less than 50 rcent.

Al e Major Markets Together

e primary energy requirements of the five major ma ts in 1970 and their predicted needs by 1985 are co ared in the following table:

	1970	1985	Change	
	Thou.Bbls.Daily*		TBD*	Percent
Tr ıortation	8,013	13,715	+ 5,702	+ 71.1
Inc rial	10,557	16,645	+ 6,088	+ 57.7
Commercial	1,689	2,930	+ 1,241	+ 73.5
Residential	4,567	6,845	+ 2,278	+ 49.9
Electric Utilities	8,154	23,580	+15,426	+189.2
Total	32,980	63,715	+30,735	+ 93.2

**Oil Equivalent*

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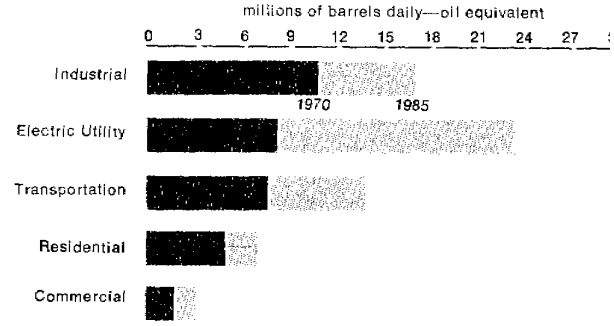
As the table reveals, the nation's over-all requirements for primary energy, are likely to be almost twice as large in 1985 as in 1970. The average annual rate of growth for the 15 year period will be 4.5 percent. And the accumulated consumption will be nearly twice as great as in the preceding 15 years.

Clearly evident are the enormous future needs o' e nation's electric utilities. Their requirements alone will re :- sent more than one-third of all energy needs by 1985. d the expansion of their requirements between 1970 and 5 will be equal to as much as half of the combined growth ll five of the major markets. As discussed earlier, the ex :- tionally large growth in prospect for the Electric Uti s market reflects not only the rapidly developing new use r electricity but also the large scale substitution of elect y for the use of primary energy in the Industrial, Comme l, and Residential markets.

Although the five major markets vary substantially in :, no single one can be considered more important thar e others. All are essential. And none can be denied a y adequate supply of energy without impairing the nat s economy and its standard of living.

ENERGY USE — By Markets



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